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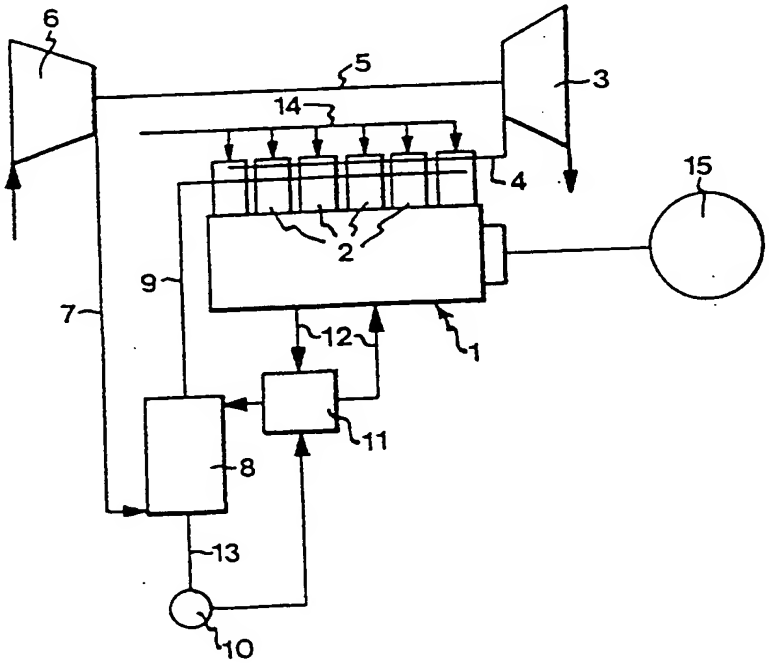
(54) Title: METHOD FOR SUPPLYING VAPOUR TO THE INTAKE AIR OF AN INTERNAL COMBUSTION ENGINE, AND DEVICE THEREFOR

(57) Abstract

The invention relates to a method for supplying vapour to intake air that is supplied to an internal combustion engine (1). The method comprises the steps of compressing the intake air before supplying the vapour contacting, in a moistening means (8), the intake air with liquid, by simultaneously feeding the compressed intake air and the liquid into the moistening means (8) and causing the intake air and the liquid to flow in opposite directions through the moistening means (8). The invention also relates to a device for supplying vapour to the intake air of an internal combustion engine (1), to which a compressor (6) for compressing the intake air is connected. The device comprises a moistening means (8), which is connected between the compressor (6) and the engine (1) and which comprises a first connection for feeding the water into the moistening means (8) and a second connection for feeding the intake air into the moistening means (8), the moistening means (8) being adapted to carry out the supply of water vapour to the intake air by contacting the intake air and the water with each other, while flowing in opposite directions through the moistening means.



# METHOD FOR SUPPLYING VAPOUR TO THE INTAKE AIR OF AN INTERNAL COMBUSTION ENGINE, AND DEVICE THEREFOR

The present invention relates to a method for supplying vapour to the intake air of an internal combustion engine, and a device for carrying out the method.

The principle of supplying water vapour to the intake air of the engine is known. This is effected in, inter alia, so-called turbo-charged internal combustion engines. Such moistening of the air yields, above all, a reduction of emissions of nitric oxide. This is of particular interest in engines which operate with excess air and therefore cannot be provided with three-way catalysts. It is also known to supply, in the same manner, evaporated fuel to alcohol-powered engines.

A device for supplying water vapour to the intake air of the engine is disclosed in Patent Specification US-4,632,067. In this device, like in other known devices applied in the same manner, water vapour forms by direct heating of the water by a heating element, whereupon the water vapour is mixed with the air that is supplied to the engine. This technique of evaporating the water requires high-grade energy in relatively large amounts. Moreover, the regulating of the amount of supplied water vapour (or some other vapour) is difficult, since the vapour must be supplied in a well-balanced amount per litre of air for optimum results and, frequently, the flow of the intake air strongly varies during short periods.

A basic object of the present invention is to provide a method for supplying vapour to the intake air and a device for carrying out the method, which eliminate the above-mentioned drawbacks of the prior-art technique and drastically reduce the levels of nitric oxide emissions in an internal combustion engine and simultaneously increase the degree of utilisation of the fuel.

The basic object is achieved by a method and a device according to claims 1 and 5, respectively. By direct evaporation of the liquid in the intake air that is obtained, it is possible to achieve, as a special advantage, self-regulation of the amount of vapour in the intake air, and therefore no separate regulation of the amount of air in the intake air is required.

A further object of the invention is to recover the energy for the evaporation from low-grade waste energy produced in the combustion process in the engine.

This object is achieved by a method according to claim 2 or 3 and by a device according to claim 7 or 8

Below follows a more detailed description of preferred embodiments of the method and the device according to the invention. Reference is made to the drawing, in which the only Figure shows an internal combustion engine to which an embodiment of the inventive device is connected.

The Figure illustrates an internal combustion engine 1 with six cylinders 2. The engine is a turbo-charged diesel engine. The turbocharger comprises a turbine 3, which is connected to the exhaust gas side of the engine 1 via an exhaust gas conduct 4. The turbine is, via a shaft 5, connected to and drives a compressor 6 for compressing the air supplied to the engine 1 on the intake side thereof via a first air conduct 7. Between the compressor 6 and the engine 1 a moistening means 8 is arranged, which in this embodiment is a moistening tower 8 connected for supplying water vapour to the intake air before its being supplied to the engine 1 via a second air conduct 9. The water vapour is produced from water supplied from a tank 10, via a heat exchanger 11, to the moistening tower 8. In the heat exchanger 11, the water is heated by the engine cooling water, which circulates past the heat exchanger 11 via a conduit 12. The water is fed into the upper part of the moistening tower 8, while the air is fed into the lower part of the moistening

tower 8. The water is dispersed in the moistening tower 8 by means of a nozzle (not shown) to a mist which falls down, and is then again collected at the bottom of the moistening tower 8, from which it is discharged to the tank 10 via a conduit 13. At the same time, the air is fed under pressure into the moistening tower 8 and flows upwards and out into the second air conduct 9. In the moistening tower 8, the air and the water are contacted with each other, while flowing in opposite directions. Fuel is supplied to the engine 1 via a fuel lead 14, and the engine is connected to a generator 15.

The supply of vapour occurs as follows. The intake air is compressed in the compressor 6, which, via the shaft 5, is driven by the turbine 3, which in turn is driven by the exhaust gases of the engine 1. The compressed and, thus, heated intake air is conducted to the lower part of the moistening tower 8, but, where appropriate, above the water that is collected at the bottom of the moistening tower 8. Water is collected from the tank 10 and fed into the upper part of the moistening tower 8 and has on its way passed through the heat exchanger and become heated. In the moistening tower 8, the water is dispersed to a mist and passes, while falling down through the moistening tower 8, through the intake air flowing up through the moistening tower 8. Part of the water is evaporated and accompanies the intake air out of the moistening tower 8 and into the combustion chamber of the engine 1. A significantly greater flow of water is thus supplied as compared to the flow of water that is evaporated. Consequently, the evaporation energy is taken from the actual water. This is called enthalpy change. When the evaporation of water is effected in this manner in a gas mixture, the evaporation occurs at considerably lower temperatures than in case of only water being present, such as in the prior-art technique, owing to the evaporation occurring at the partial pressure which, for the time being, the water vapour

exerts in the gas mixture. This implies that the evaporation close to the point where the air is supplied to the moistening tower 8 will occur at a very low temperature so as to increase upwards through the moistening tower 8 as the moisture content and, thus, the partial pressure increase. When a powerful evaporation as mentioned above occurs at a relatively very low temperature, it becomes possible to use low-grade energy for the evaporation process. Low-grade energy is obtained in great amounts as excess heat from the engine 1 in the cooling water or exhaust gases. Thus, the cooling water, as mentioned above, the exhaust gases, or both can be used for preheating the water before its being supplied to the moistening tower 8.

Preferred embodiments of the method and the device according to the invention have now been described. These should be considered as examples only, and many modifications are feasible within the scope of the invention, as defined in the accompanying claims. For example, instead of water any liquid that is desirable and suitable can be evaporated. The nozzle which disperses the liquid can be replaced by e.g. an arrangement over which or through which, depending on its design, the liquid flows towards the bottom of the moistening means.

CLAIMS

1. A method for supplying vapour to intake air that is supplied to an internal combustion engine (1), comprising the step of contacting, in a moistening means (8), the intake air with liquid, the supply of vapour being carried out by the steps of simultaneously feeding the intake air and the liquid into the moistening means (8) and causing the intake air and the liquid to flow in opposite directions through the moistening means (8), c h a r a c t e r i s e d by the steps of compressing the intake air before supplying the vapour, and using the energy inherent in the cooling water or exhaust gases of said engine (1) for preheating the liquid before feeding thereof into the moistening means (8).

2. The method as claimed in claim 1, c h a r a c t e r i s e d by the steps of feeding the liquid into an upper part of the moistening means (8); dispersing the liquid to a mist; letting the mist fall freely down through the moistening means (8); feeding the intake air into a lower part of the moistening means (8) and letting the intake air flow up through the mist.

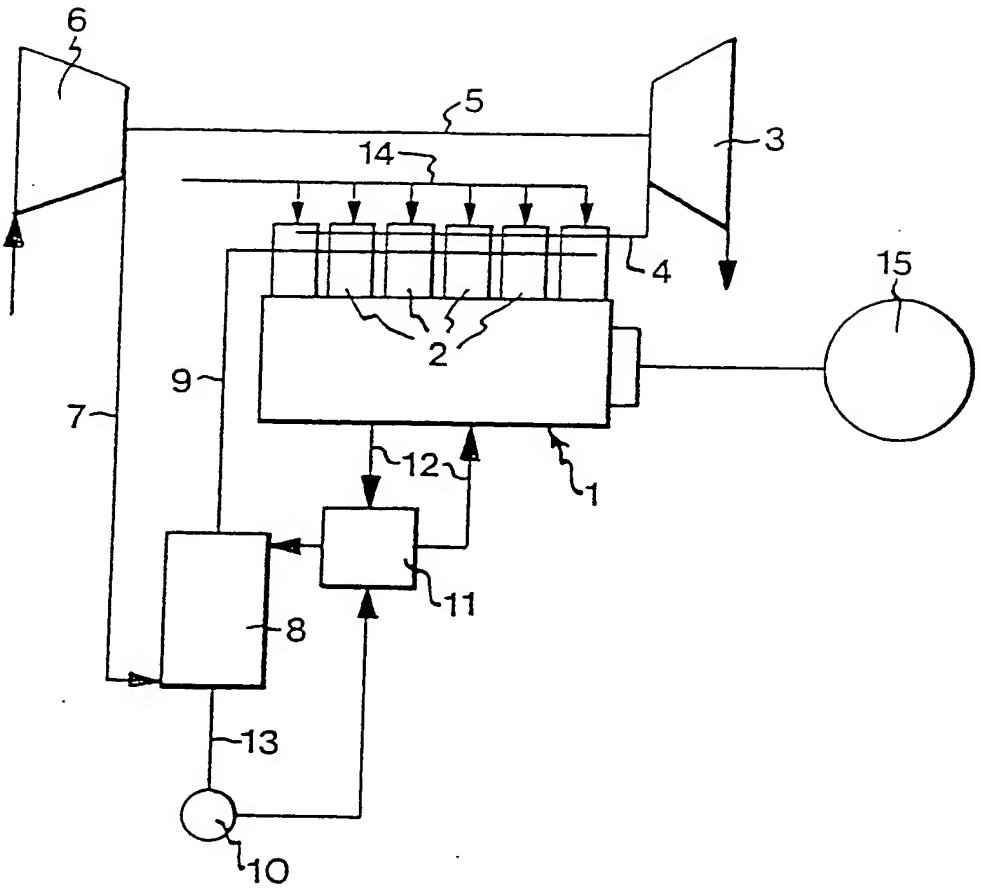
3. The method as claimed in claim 1 or 2, c h a r a c t e r i s e d by the steps of feeding the liquid into an upper part of the moistening means (8); spreading the liquid over a body arranged in said moistening means (8) and letting the liquid flow downwards along said body; and feeding the intake air into a lower part of said moistening means (8) and letting the intake air flow upwards along said body.

4. A device for supplying vapour to the intake air that is supplied to an internal combustion engine, said device comprising a moistening means (8) which has a first connection for feeding liquid into the moistening means (8) and a second connection for feeding the intake air into the moistening means (8), said moistening means

(8) being adapted to carry out the supply of vapour to the intake air by contacting the intake air and the liquid with each other, while flowing in opposite directions through said moistening means (8), c h a r a c - t e r i s e d in that said device further comprises a preheater (11) which is connected to the first connection of said moistening means (8) for preheating the liquid before feeding it into the moistening means (8), said preheater (11) being connected either to the cooling water or to the exhaust gases of said engine (1) for transmitting the energy inherent in said cooling water to said liquid, and that the second connection of said moistening means (8) is connected to a compressor (6) adapted to compress the intake air and connected to the engine.

5. The device as claimed in claim 4, c h a r a c - t e r i s e d by a nozzle which is arranged in the upper part of said moistening means (8) and which is connected to said first connection for spreading and dispersing the liquid to a mist.

6. The device as claimed in claim 4 or 5, c h a r - a c t e r i s e d by an arrangement which is mounted in said moistening means (8) and along which the liquid flows downwards.



# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 95/00026

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F02M 25/035
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F02B, F02D, F02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CLAIMS, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US, A, 4423704 (PERSINGER), 3 January 1984 (03.01.84), abstract<br>--- | 1-6 |
| A | Derwent's abstract, No 87- 35653/05, week 8705, ABSTRACT OF SU, 1236132 (KRIVOV VG), 7 June 1986 (07.06.86)<br>---<br>-------- | 1,4 |

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>Erik Torle<br>Telephone No. +46 8 782 25 00 |

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